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In Search of Broadband:
To the Last Mile and Beyond

BY KEVIN WERBACH

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Of all the Internet revolutions yet to come, none tantalizes us more than broadband. High-speed, always-on data connections to the home were already the subject of significant discussion – and promises – when the Mosaic Web browser turned the computer world upside down in 1993. Technologies such as digital subscriber line (DSL), cable modems and fixed wireless were originally envisioned as new ways to bring video or proprietary data services into homes, long before the Internet tidal wave hit. Yet mass-market adoption of broadband remains limited.

Help is on the way. . . though after everything that has transpired it would be foolhardy to predict when it will arrive. Broadband to the home and to small businesses will *change everything. It will do so by making possible new classes of applications, and by opening up whole new platforms* for *applications. Those platforms are the legacy communications networks that carry the bulk of the Internet's traffic, but have yet to adopt its open model. The Internet model will take broadband's capacity and turn it into a launching pad for innovation.*

Like most network-driven revolutions, broadband will gather strength gradually and silently until we reach a magical tipping point of service availability, consumer adoption and killer applications; then it will explode. The outlines of that tipping point are emerging from the mist. User numbers are getting big enough to tempt major media and technology providers to deliver broadband-specific offerings. Just as important, infrastructure companies are creating platforms that make it easier for third parties to develop and deploy services that integrate with broadband networks.

{ *continued on page 2* }

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Admittedly, the broadband-fueled Internet 2.0 we described more than two years ago (SEE RELEASE 1.0, FEBRUARY 1999) is still largely a vision. Sure, there will be roughly 20 million broadband subscribers worldwide by the end of 2001, but that's a small sliver of the total Internet population. And most of those users are in North America, where surveys project 10 to 18 percent home broadband penetration by the end of the year, compared to three percent in Europe.

Moreover, most of those so-called broadband subscribers get inconsistent real-world bandwidth of 200-300 kilobits per second downstream, and less than 100 kilobits upstream, far less than a 1.5 megabit per second T1 line. That's enough for a better Web-surfing experience, but hardly a world-changing torrent of speed.

Then there are the train wrecks. Dozens of high-profile data-oriented competitive local-exchange carriers (CLECs) and others aiming to provide broadband to the home or to small businesses are shuttered or in bankruptcy, including Northpoint, Flashcom, Teligent, Winstar, RedConnect and Harvard.Net. Companies such as Excite@Home have seen their stocks plummet and their strategies collapse. Even proud AT&T has been humbled in its efforts to reach into homes with cable-based data and telephony services.

The basic problem is the same as it has always been. The magnificent, open, competitive, dynamic Internet encircles the globe, but it runs into a barrier at the "last mile" into users' homes. That barrier is simultaneously technical, economic and regulatory. It will take developments in all three areas to breach it.

The technology industry is finally waking up to the importance of the last mile. Companies such as Cisco that for years urged government to do nothing more than "keep its hands off the Internet," now plead with policy-makers to promote broadband deployment.

The reason is simple: The last-mile gap is a huge barrier to innovation and consumer spending on technology. In the US alone there are more than 100 million households, and 8 million small to medium businesses (more if you count sole proprietorships). So long as they remain second-class citizens in the Internet economy, the Net

will not reach its potential. They will be shut out from a wealth of new entertainment, commerce and community services, and fewer of those services will be created in the first place because of the limited market. (For some early examples of pre-broadband converged services, SEE RELEASE 1.0, APRIL 2001.)

A recent Brookings Institution study concluded that ubiquitous broadband deployment could add an additional $500 billion to the US economy.[1] Even post-crash, McKinsey estimates that in 2005 US broadband application revenue could top $32 billion annually, roughly the total size of today's US broadcast industry. Companies such as those we describe below are putting into place the foundations for this new broadband industry. (SEE RESOURCES SECTION FOR CITATIONS.)

Who Lost Broadband?

Drawing the wrong lessons

So why, despite the rosy predictions, is broadband not further along? The easy answer is that there were too many companies chasing those rosy predictions about deployment and bandwidth demand, and too little attention paid to the minefields of the last mile. Customer adoption simply wasn't strong enough to recoup massive buildout costs, especially as the liberal funding environment evaporated.

Or maybe it's that we face not a shortage but a glut of bandwidth, with more capacity than users will soon want or need. (This debate is a hardy perennial; SEE RELEASE 1.0, JUNE 1998.) *The Wall Street Journal* last month reported that less then three percent of long-haul fiber capacity is being used. Others, such as House Energy and Commerce Committee chair Billy Tauzin, blame regulators for vainly forcing competition into the last mile, rather than accepting it as the natural domain of incumbent telephone companies and cable operators.

These diagnoses are misleading. To the first argument, the Internet thrives because it *wastes* bandwidth. It drops packets on the floor rather than over-engineering to avoid that situation, just as the Web allows you to create links that go nowhere except to mysterious "404 Not Found" errors, avoiding the centralized complexity that doomed previous hypertext systems.

[1] The contours of the broadband market vary from country to country. Though we focus primarily on the US market in this issue, we note where there may be different opportunities in Europe or elsewhere.

The question is not how efficiently networks are being utilized; it's how valuable those networks are to those using them. Metcalfe's Law doesn't say anything about capacity; it talks about the way value increases with scale of use. (Ethernet, Bob Metcalfe's greatest creation, embodied this philosophy and took collisions as a given rather than weighing the network down with central traffic-management schemes.)

Fiber in the ground isn't useful for very much unless it's "lit" with electronics and optical switches, which can cost many times more than laying cable (which is virtually free on a marginal basis). And carriers will have incentives to light up their fiber and take advantage of its potential when there is enough demand at the endpoints of the network . . . which comes back to the dearth of broadband applications.

To the policy argument, the problem is not that the last mile is regulated. As we've pointed out before (SEE RELEASE 1.0, FEBRUARY 1999), incumbents always argue that they can deploy new services only in an environment that guarantees them risk- and competition-free profits. The Internet has proven otherwise, that innovation thrives when there is open competition and the possibility that taking an up-front risk will be rewarded later with a huge return.

Further deregulation of the local telephone and cable monopolies at this stage will reduce competition and the incentives for new players to enter. Regional Bell operating companies (RBOCs) already control some 90 percent of the DSL market in the US, despite surveys showing that customers want choices and give RBOC DSL services lower satisfaction ratings than those from independent providers. Having squeezed out competition, incumbents will deploy broadband when they feel like it. Relying on their goodwill to roll out services quickly is simply naïve.

The (superior) alternative is not necessarily more regulation. Governments should articulate a firm commitment to open platforms, which in many cases may be adopted voluntarily or through merger reviews rather than mandatory rules. Second, government should promote as many alternative broadband routes to the home as possible, including cable, DSL, fiber and wireless technologies.

Novel ideas in this regard include community-owned fiber backbones (see page 21) and "open spectrum" policies to encourage unlicensed wireless technologies (the topic of a future issue). Direct government investment is also an option. France has announced plans to offer $1.3 billion in cheap loans to spur a broadband rollout it hopes will cover the entire country by 2005, and the US Congress is considering tax credits for broadband deployment in rural areas.

What's really going on

Broadband hasn't failed because it hasn't happened yet. And it hasn't happened because, unlike the Web, eBay, ICQ, or long-distance telephone competition, broadband requires changes in the infrastructure of the last mile. In other words, broadband services need broadband pipes. This leads to two problems. First, the existing pipes into the home are controlled by monopolies with legacy networks and mindsets geared more toward protecting their turf than toward opening space for innovation. Second, there has so far been no viable alternative to those existing pipes.

"Telecom is the last bastion of legacy," says Soma Networks ceo Yatish Pathak (see page 13). "It should go the way of the PC – enhancing productivity, serving the users, making it much more competitive than the IBM days when all you could do is buy a mainframe." To get to that point, companies such as Soma, Narad Networks, 2Wire and Ucentric are giving service providers the incentives and wherewithal to create true broadband service platforms. Also, service providers are seeing themselves as being in the broadband business rather than tying themselves to a specific access technology. EarthLink, for example, has 200,000 broadband users on DSL, 75,000 on fixed wireless and 75,000 on cable modems, according to ceo Garry Betty.

On the regulatory front, efforts to force cable operators to offer open access to their broadband platforms have failed in court but largely succeeded in the field (SEE RELEASE 1.0, JULY/AUGUST 2000). AT&T and AOL Time Warner, the two dominant cable players, have agreed to allow other ISPs to share access to their networks under pressure from antitrust regulators. EarthLink will begin offering cable modem service on Time Warner systems in Columbus, OH and Syracuse, NY in September, and also has deals with AT&T, Charter, Cox and Comcast. As we've noted (SEE RELEASE 1.0, FEBRUARY 1999), open access will actually benefit the cable operators by harnessing the marketing efforts of other service providers to sign up broadband customers.

On the telco side, ISPs and CLECs claim that although incumbent carriers are required to allow interconnection with their networks, they have thwarted would-be competitors' efforts. The policy battle is now over whether to further deregulate the RBOCs (the Tauzin proposal mentioned above), or to impose further controls. States such as Pennsylvania have even floated the idea of splitting up the RBOCs, though this idea has gained only limited traction.

Though the regulatory battles are important, they occur too slowly to change the near-term dynamics in the market. The immediate future of broadband will be shaped by the services network operators and their partners offer their customers.

The True Future of Broadband

Chickens and eggs

Repeat after me: Broadband is not just faster connections.

To take off, broadband requires an ecology of three primary elements: long-haul pipes, local networks and killer apps. That's the same blueprint the Internet followed in the late 1990s. It rode the growth of high-speed backbones run by operators such as UUNet, Sprint and PSINet; local connections from ISPs such as AOL and EarthLink; and valuable applications such as the Web and email. Each of those elements was available earlier in a limited, proprietary form: private lines and T1 data circuits, value-added networks and proprietary online services. Combining them through open protocols such as TCP/IP, SMTP and HTTP sparked a revolution.

In the broadband case, all eyes have been on the pipes. In most of the US, you can buy a high-speed connection via DSL or cable modem for $40 to $50 per month. Somehow, though, that price is both too high for many consumers and too low for service providers to make money. The elements for success aren't yet in place.

If broadband simply means faster Web surfing, it's not surprising that most users pass. Since the early days of the commercial Web, the real speed of dial-up connections has increased significantly, thanks to modems upgraded from 2400 kbps to 14.4 kbps to 56 kbps and network-based enhancements such as content-delivery networks (SEE RELEASE 1.0, DECEMBER 1999), server farms, load balancing and bigger backbones. Where dial-up feels faster than one would expect, so-called broadband feels slower. Service providers routinely over-promote their offerings – "100 times faster than dial-up!!!" – ignoring limitations such as shared capacity among neighbors and server bottlenecks on many Websites that cut into real-world performance.

Moreover, only some quantitative changes pass the magic threshold across which they seem qualitatively different to users. Cable television is the paradigm case. Why would people pay $30, $50, even $80 per month for television when it's available free over the air? In the real world, about two-thirds of Americans find the greater variety of programming and better reception that cable offers worth the price. That variety incentive won't work for the Net. The Net doesn't offer just more channels; it offers an infinite number of channels. There is no limit to the Websites you can visit or the streaming radio stations you can tap into. Simply offering more content, or higher-resolution content, isn't enough to convince users to ante up. At least, that's what @Home and its broadband competitors have found.

What's needed are new applications, applications that can exist only in a broadband environment. Those applications, though, depend on network connections extending beyond the PC. Home networks (SEE RELEASE 1.0, DECEMBER 1998) have been slow to take off because they have been sold primarily for shared Internet access, in other words, without the applications that can take advantage of them.

The difficulty is that it's almost impossible to know what those applications will be ahead of time, any more than we could have predicted the Web or Napster from the vantage point of the 1980s. Ucentric ceo Rick Edson (see page 18) draws a historical analogy: "The reality is this is like the early days of electricity and having a debate over what the killer app is going to be for electricity. Is it the lightbulb, the refrigerator, or something else? The reality is you can use it for all those things."

Still, we can discern some broad outlines. Users love to communicate with one another (email, instant messaging); they love to share and discover media (Napster); and many of them love games (Playstation). Spreading those existing services throughout the home, and bringing people closer together (for example, letting grandparents see videos of their grandchildren and letting parents check in on kids and babysitters) hold great potential. The key is to make it easier for networks to respond to user demands, so that providers can experiment and find the right mix.

Who defines the services?

Great broadband applications and services won't just appear; they have to be created. But who creates them? The traditional model for network-based services such as telephony and cable is for the network operator to define the applications for end-users. Your phone company offers you voicemail and call-waiting; you can choose to pay for the service or not. Third-party developers have only one choice: convince operators to deploy their applications on their networks. This model restricts the number of applications available as well as the flexibility of those applications.

The Internet model is different. ISPs and online services such as AOL can offer their own applications to customers, but in addition third parties (or end-users themselves) can deploy applications. Users aren't locked into a pre-defined set of choices, and service providers can reach customers directly rather than through a connectivity provider. This freedom of innovation, allowing individuals and companies to create myriad new services and to tailor those services to the needs of users, has created the vibrant online world we enjoy today.

Service creation environments for broadband networks are the key. Existing cable and telco infrastructure, such as the advanced intelligent network (AIN) and SS7 signaling platform of the telephone network, was designed with the assumption that only internal engineers would be able to create services. As Soma Networks' Pathak observes, "AIN failed because you needed a PhD in state-machine design to write an application. It wasn't an arbitrary application creation environment."

An open service-creation environment would allow others to develop applications that interface with the control, routing, management, database, directory, storage, billing and payment elements of the network. That obviously requires good end-to-end and internal security, to prevent malicious or malformed applications from crashing the network. It also requires mechanisms for allocating resources (such as bandwidth and storage) based on application needs. A Napster-like music-sharing service has different requirements from a four-way conference call, for example.

So far, the companies we describe below are still at the evangelism stage with developers. It helps that several of them use standard application-development platforms such as Java and Linux. Despite this, overcoming the historic gap between those who create Internet applications and those who develop (or manage or provide) services on the phone network will take time.

The broadband business case

The other reason broadband service providers have failed is economic. Neither telephone nor cable networks were designed for data transmission. DSL and cable modems let those networks support high-speed two-way Internet connections, but only with significant upgrade investments. Those upgrades, plus the cost of network and customer-premises equipment such as servers, line cards, multiplexers and modems, make it an expensive proposition to deliver broadband to each customer. Anyone other than the incumbent local phone company must also pay to interconnect with the local loop, and go through the often arduous process of negotiating interconnection arrangements.

For incumbent cable and telephone operators, deploying broadband services may be worth it anyway as means of reducing customer churn and leveraging existing network resources. But those operators then have incentives to raise prices whenever they are not threatened by competition (something several RBOCs have already done in the wake of the failure of the data CLECs) or to cut back on speed and performance to reduce their costs.

When broadband data connectivity is combined with voice services and other revenue-generating applications, it can be extremely profitable. But there must be an easy path for incumbents to reach this point, and for new entrants to compete against them. AT&T tried buying cable systems and upgrading them with cable telephony equipment, but in recent months its strategy has collapsed as the costs became apparent. AT&T is now looking to spin off its broadband assets . . . though Comcast's recent bid to acquire AT&T Broadband may alter those plans.

The solution is one part technology and one part psychology. We discuss some of the technologies below. The psychological problem is that network operators always want to control everything. They hate the idea of being nothing but a dumb pipe. On the other hand, building pipes is what cable companies and telcos are good at, not developing applications, selling hardware and providing effective customer service. There must be space for third-party innovation, as on the narrowband Internet, for broadband to reach its full potential.

As Narad Networks co-founder Andy Chapman (see page 10) notes, "You don't want the network provider to only be a provider of pipes, because that's not interesting enough to them. But you also don't want the network provider to have to create all the services themselves."

Reasons for optimism

Fortunately, there is reason for optimism. The demand for broadband has always been there, and the years of promises and promotion have only increased the pent-up desire for a true broadband option. More broadly, customers want choices for their communications services, both in terms of providers and in terms of services.

The real-world evidence for the value of new broadband applications is hard to grasp because so few people have experienced much more than faster Web surfing. But it's out there. We have yet to find a person with a Tivo personal video recorder who doesn't say, "It changes the way I watch TV, and I can't see how I could have lived without it!" *[For months I was the one exception, because I couldn't hook my Tivo into my cable set-top box properly. . . but I've now seen the light. –KW]*

The trouble is Tivo still costs too much – at least $500 when service is factored in – for mainstream adoption. And there are many minor irritations that make Tivo harder than it should be to install and use. But these things can and will change. What matters is that the application is immensely useful to a vast number of people.

Miracles in the Last Mile

Overcoming the last-mile bottleneck by brute force is a hopeless exercise. Short of regulatory intervention to split off the local loop into a quasi-public utility separate from the retail service functions of the RBOCs, it will be difficult for any competitors to gain traction through simple interconnection or resale. On the cable side, operators see the broadband opportunity but they are finding deployment a slow, costly process.

Breaking out of this stalemate requires new approaches, which fortunately are now appearing on the scene. A handful of startup technology providers are rethinking broadband architecture from a clean sheet of paper. Compared to previous efforts such as AT&T's wireless Project Angel and data CLECs such as Covad and Northpoint, these are both more comprehensive in terms of end-to-end platforms, and more evolutionary in dropping into existing infrastructure and business plans.

Narad and Soma Networks have both come up with powerful new approaches to the last mile. They are still in the trial stage so skepticism is appropriate, but if they can deliver on their claims and win big customers they could shake up the industry. Narad focuses on delivering truly high-speed data connections (100 mbps and up), as well as new services and applications, to homes and small-to-medium businesses, initially over cable networks. Soma makes it possible for competitors to the incumbent operators to offer complete voice phone service, along with high-speed Internet access and innovative new services, over fixed wireless links.

Both have a similar idea: the need for a broadband network operating system to facilitate new applications. Both use a combination of customer-premises hardware, network software and back-end systems, with Java as an enabling technology. From there, though, their implementations diverge, with Narad focused more on true broadband data connections and Soma taking on local telephony competition.

Narad Networks: more bandwidth. . . and more than bandwidth

Narad's co-founders, ceo Dev Gupta and evp Andy Chapman, are on their third networking startup together, having previously sold both MaxComm and Dagaz to Cisco. From their experience working with broadband technologies since 1991, they say they've learned to combine strong technology with a pragmatic approach to service providers' business needs. They also believe they've identified the key missing

link in the broadband chain: a true broadband network operating system. And with Narad they believe they have the solution. Says Chapman: "The inspiration was, to put it crudely, to make broadband happen. Dev recognized that just solving the bandwidth problem was not solving the broadband problem."

NARAD NETWORKS INFO

Headquarters: Westford, MA
Founded: July 2000
Employees: 145
Funding: $49 million from Polaris and individuals including founders, Sonus chairman Rubin Gruber, Sonus president Hassan Ahmed, Juniper founder and cto Pradeep Sindhu and Bob Metcalfe
URL: www.naradnetworks.com

Gupta elaborates: "When you use desktop applications like word processing or spreadsheets, you can learn from one to fuel the other. But when you use networked applications – you make a voice call, you watch TV, you browse the Internet – there is nothing in common." The glue that ties together applications on the PC is the OS, which manages how applications use resources and provides a common development platform and runtime environment. (This line of thinking parallels that of the infrastructure-oriented P2P companies, such as OpenDesign, that we've profiled (SEE RELEASE 1.0, DECEMBER 2000).

"The management and control of the application is generalizable into a virtual machine architecture," says Gupta. Narad created a software gateway that turns nodes on the broadband network, whether residing in the carrier infrastructure or in customer-premises devices, into Java virtual machines capable of securely running applications that control network functions. The applications are linked into a directory-enabled network, which provides a global view of network topology, databases and servers. Chapman offers an analogy: "In some ways it's analogous to what Akamai does today in directing you to the fastest way to get to a Website."

All of this makes sense only on a network with sufficient capacity and reliability. "The broadband network itself better be capable of enough bandwidth that you stop thinking about bandwidth," says Gupta. And it must simply work, he continues: "Just like you buy a refrigerator, plug it in to a socket and think it will work. You don't worry about the current." Now it's more like being a traveler to foreign parts each time you try to plug something in.

To address these needs, Narad developed technology using cutting-edge silicon germanium chipsets that runs on top of cable networks and effectively turns them into 100 megabit-per-second (Mbps) or gigabit switched Ethernets. It is also creating software and management infrastructure for broadband data centers to host the servers and gateways that allow voice-over-IP, media services and other application service providers (ASPs) to integrate with the platform.

LIFE WITHOUT WIRES

Until fiber to the home takes off (see page 21), terrestrial or satellite-based wireless technologies are the only economical last-mile alternatives to incumbent cable and phoneline connections. Hundreds of millions of people use mobile phones, but fixed-wireless technologies have never lived up to expectations. Teligent, Winstar, Britain's Ionica and AT&T's Project Angel have all struggled with a mix of technical, reliability and business challenges.

Soma Networks (see page 13) is one company betting it can overcome these limitations, but it's hardly alone. AirSpan Networks, based in Fort Lauderdale, FL and Uxbridge, England, also believes it can make fixed wireless work, and though its vision is less grand than Soma's, it has real customers and over $8 million in quarterly revenue. The company, which went public last year, provides equipment to more than 50 service providers in 40 countries, supporting both voice and data connections over licensed spectrum between 900 Mhz and 4.0 GHz. Small-to-medium businesses and small office/home office users are its primary market.

Smart networks with smart edges

From Narad's perspective, just providing an unadorned high-speed IP pipe isn't enough. As Gupta and Chapman acknowledge, that doesn't mean we need to return to the centralized, application-specific, intelligent network model of the traditional cable and telco operators. Instead, they say, putting certain kinds of general-purpose intelligence into the broadband network is essential to enable smart edge devices to create and control new services. "The network doesn't have to be so stupid that you can't do anything with it," observes Gupta.

For example, says Gupta, say a service provider wants to deploy a video-on-demand service. Today it has to install expensive specialized streaming-media servers in the network, which pushes costs to $800 per stream and scales poorly. But if the network is smart enough to handle bandwidth contention, latency and resource allocation, and ties devices together through standard interfaces, a different architecture becomes possible.

A set-top box in the home, equipped with a software virtual DVD player, can reach into a storage-area network in the broadband data center and pull in a video file through a remote file system. The network caches the media files in the most appropriate place so that two people are pulling the same movie at the same time. The set-top thinks it's playing a local DVD. Costs plummet because everything uses standard general-purpose components.

The business case for cable operators is compelling. A Narad customer could deploy incrementally, starting at $10,000 for the first business in a node and averaging down to $5,000 or less per business once eight sign up. In the US, most cable operators have already upgraded their networks for data and deployed cable modem services, so Narad's initial strategy is to enable them to offer high-margin data services to small and medium businesses. Narad says there are 8 million such businesses in the US, of which 5 to 6 million are passed by cable networks and 2 million already sub-

scribe to cable video services. And these customers are generally stuck with indifferent incumbent telcos if they want to order data services. “Getting a T1 line takes an act of God,” says Gupta.

Narad allows cable operators to offer high-speed data connections to these customers, as well as ASP services that typically make sense only for large enterprises, such as networked backup. “If we can hook together a broadband network, and from this network can see these small businesses, we can aggregate the small businesses virtually and look like a big business,” Gupta explains. Because of the price points and concentration in the business market, Narad estimates that cable operators can double or even triple their cable cash flow with only modest levels of penetration.

Once the operators deploy Narad’s platform for business, the incremental marginal cost to serve residential customers is less than $500 per subscriber. “The business cases for broadband services for consumers like video-on-demand now become relative no-brainers, because they are provided on an incremental basis,” says Gupta. Where cable operators haven’t yet incurred the sunk costs to upgrade their networks for digital services, as is the case in much of Europe, Narad customers can more easily justify starting with residential services.

Narad is now in the midst of system testing, with plans to go to beta in October and to ramp up manufacturing in the first quarter of 2002. It has eight cable operators interested in trials, though it can handle only four at once. It has selected three American and one European operator initially.

Soma Networks: transformers of the last mile

“On the surface it appears that, as one vc put it, we’re trying to boil the ocean,” says Soma Networks president and ceo Yatish Pathak. Indeed, institutional investors passed on Soma, which managed to raise a remarkable $70 million from angels. Pathak says that’s enough for all the product development and field trials to the end of this year, after which the company plans to do a mezzanine financing round. What made the venture capitalists skeptical – and excited the angels – is the scope of Soma’s ambition: nothing less than to replace the entire local telephone infrastructure with a fully converged network.

SOMA NETWORKS INFO
Headquarters: San Francisco, CA
Founded: 1998
Employees: 250
Funding: $70 million from individuals including Ben Rosen, Jim Manzi and Bill Bradley
URL: www.somanetworks.com

“It’s counter-intuitive,” Pathak argues, “but it’s much easier taking on the whole job from a clean sheet of paper and interfacing with

whatever is there," than extending legacy systems. Pathak drew this lesson from his years developing and managing wireless technologies at Bell Labs and Lucent, where innovations constantly ran aground on the limitations of existing networks. His co-founders hail from Canada (which, incidentally, blows the US out of the water in communications technology experts per capita). Martin Snelgrove, svp of product strategy, was a wireless and circuit design expert at Carleton University; cto Michael Stumm was a pioneer in distributed computing at the University of Toronto.

In starting Soma, they decided to reframe the last-mile problem: "We started with the goal of supporting any arbitrary application . . . and we call voice an application," Pathak says. After three and a half years in development, Soma is in trials with the carriers which will sell its products. General availability is planned for January 2002.

The three basic elements of a converged network are transport, switching and services. Soma tackles all three in innovative ways. For transport (the pipes) it developed a fixed-wireless technology that provides five to ten times the capacity of third-generation (3G) wireless systems, and unlike other fixed wireless solutions doesn't require line-of-site connections according to Pathak. For switching (network resource management) it created an end-to-end packet-based system that handles quality of service and allocates capacity dynamically based on application demands. And for services, it built a Java-based environment that makes development of network-based applications on the telephony platform comparable to the process on the Web.

A clean sheet of paper

All this takes a little getting used to. It's easy to pigeonhole Soma as a wireless broadband company, because it promises multi-megabit data rates for residential customers over its wireless links. But that's only part of the story. In reality, Soma is one of the few companies that seem able to bridge the yawning chasm between Bellheads and Netheads (SEE RELEASE 1.0, APRIL 2001).

Most Internet-oriented companies and investors are used to thinking of network equipment in terms of boxes. The data networking model is one of components – routers, servers, multiplexers, load balancers and switches – which are cobbled together. This approach makes sense for the Internet backbone, but not for telephony. Adding new modules to the legacy network in order to support voice-over-IP or new data services results in a morass of cost and complexity. Pathak points to the difficulties Sprint has experienced with its ION platform for integrated voice and data services (SEE RELEASE 1.0, JUNE 1998) as evidence of this point.

THE OTHER MILES: REMODELING THE INFRASTRUCTURE

While we emphasize the last mile in this issue, that's hardly the only area of Internet infrastructure undergoing a transformation. Today's Net is a bit like a grand old house. From the outside it looks fine, but start examining its earthquake readiness, plumbing, electrical system and insulation and you realize that bringing it up to modern standards is a massive (and expensive!) job.

We're witnessing a modernization of the Net's architecture, much like Microsoft's transition from the DOS-based Windows 3.1/95/98 code base to the newer NT code base underlying Windows 2000 and XP. As with Windows, backward compatibility is essential, and in this case that means compatibility not just with protocols and equipment but with the Internet's open, end-to-end technical architecture as well.

Startups are attacking the Net's major bottlenecks one by one. At the core of the network, the fundamental challenge is speed. The basic architecture of routers is being re-thought as performance demands increase, especially with optical technologies becoming more widespread. Companies such as Packet Design (SEE JUDY ESTRIN IN RELEASE 1.0, MARCH 2001) are doing fundamental R&D to update the Internet's routing mechanisms for these challenges. New protocols such as IPv6 (SEE RELEASE 1.0, MAY 1999) are gaining adherents.

Long-dominant Cisco finally faces significant competition from an upstart, Juniper Networks. Juniper has taken a 35-percent share of the core router market, largely because it delivers better performance. Two further generations of startups are now challenging Cisco and Juniper for the core router crown. The first includes Avici and Pluris, promising to scale routers to terabit performance levels. The second generation, just now hitting the market, includes Hyperchip and Caspian, who claim to go an order of magnitude beyond terabits into the uncharted realm of petabits. Meanwhile, continuous advances in optical networking move the Net gradually closer to an all-optical future.

The overlay "meta services networks" that sit on top of the Net and offer virtual network-wide services such as content delivery (SEE RELEASE 1.0, DECEMBER 1999) are also improving. Akamai and Inktomi have both made acquisitions and developed their own technologies to support dynamic content and streaming media, but many startups think they can leapfrog the two leaders in these areas.

In addition to the many content-delivery players claiming their algorithms blow away Akamai, a spate of new companies are offering new kinds of meta-services beyond Website performance enhancement. Bang Networks, for example, supports real-time services for massive numbers of users, while Slam Dunk Networks offers secure, reliable connections with a fraction of the cost and complexity of private lines and virtual private networks (VPNs).

Other new players sit closer to the edge of the Net. Sigma Networks seeks to eliminate bottlenecks in the metropolitan area, between the local networks we describe in this issue and the long-haul backbones. SmartPipes allows companies to do end-to-end provisioning of VPNs and to manage bandwidth usage policies through simple Web-based interfaces.

These startups address a variety of problems, many of them overlapping, but thanks to the Internet's open architecture they can peacefully coexist. As broadband applications emerge at the edge of the Net, there will be demand for other improvements to support services such as streaming video across the entire network.

By contrast, Soma's wireless technology is based on well-proven signal-processing techniques rather than any exotic breakthroughs. It uses licensed spectrum such as PCS and MMDS that carriers already control. The system's anticipated superior performance derives from its "clean-sheet" architecture. 3G, for example, was architected primarily to increase mobile voice capacity with data secondary. Other fixed-wireless technologies generally are designed for Internet access, not voice.

Soma created a system with the full needs of broadband users in mind. Each wireless base station supports 2,000 to 4,000 users, who get four toll-quality voice lines, a

multi-megabit broadband pipe, plus the firewall and router capabilities of a residential gateway through a unit slightly bigger than a DSL or cable modem.

This is where the network-management and service-creation infrastructure comes in. The back end of the public switched telephone network (PSTN) is a convoluted, proprietary mess, but it has been carefully optimized to carry voice calls and does so quite well. A true converged network built today can take advantage of all the price/performance and computer science advances of recent decades, but only if it is designed bottom-up for its full spectrum of uses.

Soma's solution is a distributed network operating system that treats every piece of the network – customer-premises gateways, switches, servers, storage devices, etc. – as a resource. Each application, from voice calls to voicemail to P2P music-sharing, has different characteristics. Voice, for example, requires high reliability and low latency, but limited bandwidth. Voicemail requires a server to store messages. Soma's OS dynamically allocates resources to meet those demands, shifting between edge and central devices and between P2P and client-server architectures as needed, not to mention hooking into carrier billing systems. Moreover, Soma's OS fits on a floppy disk – a far cry from the massive codebases of legacy telecom platforms.

The final element of Soma's vision is distributed service creation. "You've got to find out how to make the service-creation environment so easy to use that a high school guy who knows Java can create the most complex application," says Pathak. Because the OS handles allocation of memory, bandwidth and switching automatically, developers can focus on functionality. And because it's based on Java, they need not learn another proprietary development language. An application can be anything from a conference call with automatic transcription via speech recognition to a wakeup call plugged into a groupware calendar.

For US carriers, Pathak predicts Soma's technology will give long-distance operators support for an economically viable strategy to compete against the RBOCs in bundled voice services, will allow wireless operators to take advantage of their spectrum as full-service telecommunications providers, will give regional carriers full-service capability and will enable RBOCs to offer out-of-region local service more easily. In Europe, the primary driver may be the broadband capabilities of the system, since penetration rates for DSL and cable modems are so much lower than in the US.

Customers also win, Pathak argues: "For the first time, the end-user gets to pick what he wants. For the first time he is well serviced. People are asking him what he wants."

Into the Home

Broadband services involve more than just the network. Delivering new applications requires intelligence at the edge of the network, specifically the home. The basic elements involved are gateways that mediate between the broadband wide-area network and the devices in a home, network connections among those local devices and the devices themselves. (Such devices can include existing PCs and consumer electronics equipment, new appliances such as streaming audio players or digital video recorders . . . even refrigerators, ovens, window shades or garage doors!)

Since we covered it in late 1998, the home networking market has grown steadily if not explosively (SEE RELEASE 1.0, DECEMBER 1998). Linksys, the volume leader in low-end home and small-business routers, now ships close to 1 million units per year, and there are dozens of companies – large and small – competing in the market. The phoneline-based HomePNA standard has been updated to 10 Mbps and has been joined by 10 Mbps HomePNA 2.0, wireless technologies including HomeRF and 802.11b as well as powerline networking under the HomePlug alliance.

Networks in the home face the same challenges as broadband networks: the need for applications. Only so many people will buy home networks and residential gateways just to share Internet connections or printers among PCs. Still, demand exists. EarthLink ceo Garry Betty says 10 percent of his company's new broadband customers purchase the home-networking option, even though the company charges an additional $9.95 per month (plus $150 for hardware) and hasn't actively marketed it.

New companies are taking more creative approaches to foster the growth of broadband applications. Below we cover three startups – Ucentric, 2Wire and SimpleDevices. A few others are also worth mentioning. Rearden Steel, founded by WebTV ceo Steve Perlman, emerged briefly from its three-year stealth cocoon to announce it had raised $67 million from a high-profile list of investors including AOL, Cisco, EchoStar, Mayfield Fund, Vulcan Ventures, The Barksdale Group, The Washington Post and Macromedia Ventures . . . only to drop once more off the radar screen. The company will say nothing more than that it is "creating breakthrough technology to enhance the home entertainment experience." (Sadly, our sneak peek was under non-disclosure.)

Two established companies, AOL Time Warner and Microsoft, also plan to make big noises in this market soon. AOL has its AOL TV initiative (as well as investments in Tivo and Rearden Steel) and Microsoft has Ultimate TV and the Xbox gaming plat-

form. Sony, which has sold tens of millions of PlayStations capable of high-performance graphics manipulation, deserves a place on the list as well. None of these companies has yet made a significant push into broadband services or home networking. But you can bet they will before long.

Ucentric Systems: toward the next utility

Ucentric Systems has built perhaps the most comprehensive platform for in-home broadband applications. Linux-based residential gateways using its designs can offer connections for Ethernet, POTS, wireless LAN, TVs and stereos; handle either cable modem or DSL connections; include a built-in 9-gigabyte hard drive; and support for unified messaging and streaming media as well as Internet access across all devices in a home. Ucentric will license its software, including back-end provisioning and management tools, to service providers, and it will license hardware reference designs to the consumer electronics vendors who will actually build the boxes.

UCENTRIC SYSTEMS INFO
Headquarters: Maynard, MA
Founded: June 1999
Employees: 100
Funding: $27.5 million from Polaris Venture Partners and Pilot House Ventures Group
URL: www.ucentric.com

"What we have is an opportunity to provide what I would call the next utility," says Ucentric ceo and co-founder Rick Edson. Edson was most recently svp of new business at 3Com, which he joined as part of 3Com's acquisition of US Robotics. He elaborates: "It's an opportunity to power many of these devices that cut across communication, entertainment and commerce just like electricity powers many devices in the home."

The utility analogy operates on several levels. To Ucentric, broadband connectivity is an enabler rather than an end-product, but that requires standards so that different devices can be plugged into the high-speed pipe. Users shouldn't have to worry about the details of connectivity; things should just work. "People shouldn't have to know what IP addresses are; they shouldn't have to understand subnet masks; and they shouldn't have to know how to open port 282 on their firewall to play EverQuest," says Edson. Finally, service providers should be able to offer and bill for broadband services for monthly fees, similar to the way utilities sell electricity.

Ucentric's goal is to be the ultimate convergence platform in the home. Want virtual second or third phone lines using IP telephony without replacing your existing phones? Instant messages that appear on your TV (or refrigerator) screen as well as your PC, without any special set-top box or other hardware? MP3 files playing on your existing stereo? Tivo-like digital video recordings playable on every TV in your

house? Ucentric says its middleware allows all these devices, and others, to hang off a broadband pipe.

Cable, DSL or satellite operators who deploy Ucentric's gateways need make only one trip to install the hardware. After that they can provision, add or modify service offerings remotely over the broadband connection. Spinning another historical analogy, Edson compares today's local telcos and cable operators to the railroads early in the 20th century. The railroads saw much of their revenue drained away by cars, trucks and airplanes because they viewed their business too narrowly. They thought of themselves as railroads, when in fact they were transportation companies. In contrast, network service providers *want* to be more than just access points, but they don't know how.

Edson anticipates that in most cases service providers will charge customers monthly fees for bundles of services, with the hardware either subsidized or subsumed in the monthly charges. He is confident users will be willing to pay once they see the new kinds of applications Ucentric enables. "In our surveys, people were willing to pay surprisingly substantial amounts of monthly premiums to just play downloadable music on their stereos," he points out.

The company is in trials now with Rogers Cable in Canada, as well as Speakeasy.Net, a Seattle-based DSL provider. Edson says other trials will be starting soon, and he expects commercial rollouts in serious volumes next year. He sees a bright future ahead for service providers, who can increase their net present value per customer by 50 percent or more and can differentiate themselves while keeping their best customers happy by offering new services. End-users win too, he adds: "At the end of the day consumers are going to get more services for less money."

2Wire: gateway to new services

2Wire founder Brian Hinman is on his third network hardware startup, and his track record is pretty good so far. He founded PictureTel, a pioneer in videoconferencing, and then started Polycom, which makes those saucer-shaped speakerphones that seem to grace every conference room in the country. Now, with 2Wire, he's taking on the residential gateway market. Or more precisely, he's helping create it.

In contrast to most of the companies we describe, 2Wire is shipping actual products and has been doing so for some time. 2Wire offers a line of gateway devices that serve as DSL modems and also provide home-networking connections and other

2WIRE INFO
Headquarters: San Jose, CA
Founded: 1998
Employees: 160
Funding: $149 million from Accel Partners, Oak Investment Partners, Venrock Associates, Meritech Capital, Invesco and Doll Capital Management
URL: www.2wire.com

features. From the beginning, it eschewed a retail strategy and sought to sell its devices through service providers. Initially, many of those partners were data CLECs, but with the collapse of that sector 2Wire now concentrates on incumbent telcos and large ISPs. It signed deals with SBC and EarthLink, and is pursuing AOL and the other RBOCs.

Hinman expresses surprise that broadband applications and value-added services have been so slow to emerge. "When we started the company three years ago, I would not have believed there would be no major service provider doing voice-based services yet," he says by way of example. Ironically, as the collapse of local telephony competition has held back voice over IP as an offering on top of broadband, more demanding video services are pushing forward. For ILECs, video offers an opportunity to enter new markets and generate incremental margins. 2Wire has a trial involving streaming video services planned for the fourth quarter.

Voice remains an important piece of the puzzle, though. Especially for companies other than the incumbents, the ability to offer multiple voice lines over a single broadband pipe is significant both for revenue and for completeness of their offerings. "Before the end of the year we will see multiple notable service providers offering voice services," Hinman predicts.

Though 2Wire is counting on the residential gateway market to eventually take off, it's realistic about the uncertainty of when that will happen. 2Wire generates a substantial portion of its revenue today selling microfilters, which most DSL subscribers must connect to their telephones and fax machines to prevent interference with the DSL signal. Of course, microfilters sell for considerably less than gateways, but they bring in some helpful near-term revenue. 2Wire also offers a comprehensive set of DSL resources on its Website, including a database of the providers and services in every zip code. This helps the company to promote its brand while building support for broadband deployment as the market matures.

Along with its gateways, 2Wire has created a remote provisioning and service delivery infrastructure. Hinman believes this is a key element for success: "The people we are selling to are looking for a platform." Carriers want to put a device in the home that can support whatever existing or new applications they choose to offer, without requiring them to send out technicians to reconfigure it. 2Wire's Component Management System handles these provisioning and remote updating functions.

SIMPLEDEVICES: MEDIA MOVERS

SimpleDevices wants to make it easy to link up broadband connections with existing home devices such as stereos and TVs, using the PC as the control point. The company, located in Burlingame, CA, was founded in 1999 and has investments from Motorola, Proxim and Casio.

SimpleDevices makes middleware that allows media content and ancillary content to be shipped between different devices in the home. To listen to MP3 files or streaming Internet radio stations on your stereo, for example, you would connect to it an inexpensive device called a SimpleFi, or buy a stereo with the capability built in. The SimpleFi includes a small display and a remote to browse through tracks, including the capability to tag content so that it appears on a personal Web page for later listening. With SimpleDevices' software, the PC becomes both a gateway to the Internet and as a caching server to allow high-fidelity playback on the stereo.

The company is creating reference designs for other devices including an Internet-enabled clock radio, an interface that turns mobile devices such as Palms into all-device remote controls and a car stereo connector. Whether people need – or want – an Internet connection to their clock radios is a fair question, but we won't know what sorts of connected home appliances make sense until there are real examples to try out.

SimpleDevices is focused on making media interoperable with legacy devices, so it doesn't see itself in competition with other home-networking vendors. Indeed, it has a partnership with Ucentric to integrate its technology with that company's residential gateway platform.

Though it has manufactured prototypes of its devices for demo purposes, SimpleDevices sees itself as a software company that licenses middleware to consumer electronics and computer OEMs. Vp of marketing Mike Maser admits the company is mulling a name change to emphasize that it makes software, not devices.

Hinman sees an inflection point occurring in the way consumers purchase broadband services. Up to now, a customer would typically order a broadband connection for a single PC, and realize later that he or she wanted to share the connection with other devices. Few service providers today support or offer home networks, so most customers are forced to buy home-networking kits at retail and struggle to install and configure them. That's beginning to change as service providers recognize the opportunity to sell more than bare connectivity. "We're now trying, even before you get these voice and video services, to back the decision process up to when you acquire broadband service," Hinman says. That will help broadband go beyond the early adopters to a true mass market.

Hints of the Future: Private Fiber

The broadband services we describe throughout this issue use existing cable and telephone networks because those are the only affordable options today. Long-term, though, there is little doubt the network platform for broadband will be something different: fiber to the home. Fiber optic cables offer vastly greater bandwidth than even the most souped-up technologies running over copper or coaxial cable. That's why the core of the network is fiber-based virtually everywhere in the world. Service providers have been pushing fiber farther and farther into their networks, getting tantalizingly close to the last mile. But they're not there yet.

Fiber to the home remains too expensive for service providers who have already invested in existing networks to justify. After spending billions to offer cable modems and DSL, established carriers will naturally want to recoup their investments before deploying a next-generation technology. Though costs have dropped dramatically for both the fiber cables themselves and the switching equipment necessary to make use of them, they remain high for small-scale end-user deployments (as opposed to the aggregated pipes at the core of the network). Getting fiber out to where it's needed often means digging up streets, which can be both costly and disruptive to communities.

Yet fiber to the home may be closer than we think. Raj Reddy, chair of the computer science department at Carnegie Mellon University and co-chair of the US President's Information Technology Advisory Committee, described in detail in 1997 how a "national fiber grid" could be built, and costs have dropped substantially since then. Reddy is on the advisory board of LBDC, a startup now seeking funding with an audacious plan to build out fiber to the home across America and elsewhere.

The most interesting and near-term scenario for fiber to the home involves the combination of private and public efforts. Several jurisdictions, including Canada, Stockholm and a few US cities, are exploring a creative mechanism to hasten its arrival: condominium ownership.

In this arrangement, municipalities contract with fiber construction firms to do the dirty work of digging up streets and laying fiber cables throughout the local area. Having governments involved overcomes thorny right-of-way issues and ensures that the local fiber backbone gets built once rather than being duplicated unnecessarily. Private companies, organizations such as schools and even individuals can then lease individual fibers, typically through 20-year indefeasible rights of use (IRU) agreements typical in the submarine telecommunications cable industry.

As with a condominium apartment, once you buy a fiber, it's yours to keep! Those who lease fiber capacity on these systems can put whatever equipment they desire at the end of it, and thus can take advantage of increasing capacity over time as bandwidth-multiplying technologies such as dense wave-division multiplexing improve. Service providers such as Bredbandsbolaget in Sweden take the fiber made available by the city of Stockholm and use it to provide two-way 10-megabit broadband service to end-users for prices orders of

COMING SOON

- Web services.
- Online collaboration tools.
- Open spectrum.

- And much more. . . (If you know of any good examples of the categories listed above, please let us know.)

Resources & Contact Information

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Rick Edson, Ucentric, 1 (978) 823-8100; fax. 1 (978) 897-9980; redson@ucentric.com

For further reading:

Michael D. Mayer, Willhelm A. Mohn & Christian Zabbal, "PCs vs. TVs," McKinsey Quarterly, 2000 No. 3 (plus several other articles in the same issue on broadband)

Broadband!, joint industry study by Sanford Bernstein & Company and McKinsey & Company (January 2000)

Morgan Stanley Dean Witter, The Broadband Report – Reaping What You Sow: ROI in the Broadband Market (May 2000)

magnitude less than in the US. (Sweden sweetens the pot further by providing tax incentives for companies to offer broadband service, something under discussion in the US but primarily in the context of rural subscribers.)

The condominium fiber model isn't necessarily the right answer in every case or every country, but as fiber becomes cheaper and more widely available it becomes increasingly attractive. Because one thing is abundantly clear from every experience with networking technology: there's never enough bandwidth.

Once users get a taste of the benefits of always-on, high-speed connections to the home, they will find applications that take advantage of that bandwidth. Then new applications will come along that require more bandwidth, or bandwidth configured differently. Once you cross a certain threshold, broadband is a stairway leading upwards. In the coming years, we'll take the first steps. ■ R 1.0

November 7 to 9, 2001

Hotel Palace Berlin
Berlin, Germany

For 12 years, EDventure's High-Tech Forum in Europe has connected Europe's high-tech innovators with partners, suppliers, customers and competitors. Each year the High-Tech Forum attracts several hundred senior executives from Europe's IT market to focus on new technologies, new companies and new markets.

Europe in 2002: Get Connected!

Europe is learning to connect itself – through broadband or wireless, by PCs or handheld devices. And it must connect its various regions – East and West, North and South – and also its sectors – customers and vendors, startups and investors, governments and private actors.

As always, we focus on companies and trends of the future. This year, many people in Europe are breathing a sigh of relief and saying (or at least thinking): "Good, now we can get back to normal. No more of this dot-com foolishness!"

While they are right about the dot-coms, they may miss the competitive advantage the Internet is still creating for those who use it well. Companies are using the Net to respond to their customers, and the customers are using it to find alternatives to the companies that don't respond. Citizens expect more responsiveness from their governments, and employees expect more responsiveness from their bosses.

We look at business models analytically and candidly. Though it is clear that the business model of free content (for example) is troubled, so are the models of advertising, of music by the physical piece, and of telecom monopolies. What models actually work? – from online groceries to online application services, phone-based payment systems and content-enriched consumer services. The new "Europe" will have more countries, and also more diversity within. These changes are threats to those who ignore them, and opportunities for those who make them happen!

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- The bloom is off wireless: What will rescue wireless from its own mistakes?
- Who owns the mobile customer?
- Back to bricks: two case studies
- Public policy: When does the market not work?
- Content & community: What wins consumers? (and who pays?)
- Business models for infrastructure
- Business models for services
- HR & education: Are we renewing our (human) resources?
- Outsourcing: Could someone else do it better?
- Raising the ¤¤

Speakers

Anna Maria Bildt, CEO, Italiantradition.com (Italy/Sweden)
John Browett, President, Tesco.com (UK)*
Hubert Burda, Chairman, Burda Media (Germany)*
Chris Dedicoat, Group VP, EMEA, Cisco Systems (UK)*
Gianluca Dettori, Founder & CEO, Vitaminic (Italy)*
Stelios Haji-Iannou, Chairman, EasyJet (UK)
Boguslaw Kulakowski, Chairman & CEO, Polska Telefonia Cyfrowa (Poland)
Michael Lynton, President, AOL International (US)*
John Meyer, President, EMEA, EDS (UK)*
Antonio Perez, President & CEO, Gemplus (France)
Sebastian Schnitzenbaumer, CEO & founder, Mozquito Technologies (Germany)*
Karen Slatford, acting CEO, Stepstone (UK)
Christopher Spray, Senior Principal, Atlas Ventures (UK)*
Roman Stanek, CEO and founder, Idoox (Czech Republic)*
Elek Straub, Chairman & CEO, Matav (Hungary)
Andrew Tsai, CEO, Global Name Registry (UK/Norway)*
Martin Varsavsky, Chairman & founder, Jazztel (Spain)*
*confirmed

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Calendar of High-Tech Events

2001

AUGUST 13 — ICANN AT-LARGE STUDY COMMITTEE PUBLIC OUTREACH MEETING - Palo Alto, CA. Esther Dyson used to head ICANN as chairman; now she's a member of the At-Large Study Committee trying to fix it. The Committee wants to hear from a broader public than those who attend ICANN meetings, so come express your views! Details at www.atlargestudy.org, or contact Denise Michel, dmichelalsc@hotmail.com

AUGUST 16-17 — SEARCH ENGINE STRATEGIES - San Francisco, CA. Focuses on search engine marketing issues and techniques. Led by Danny Sullivan, editor of the popular Search Engine Watch site. Contact Allison Alessio, 1 (203) 662-2857; aalessio@internet.com. www.searchenginestrategies.com

AUGUST 23-26 — MEMS CONFERENCE - Berkeley, CA. Covers the global MEMS (Microelectromechanical Systems) industry. Co-sponsored by IEEE Circuits and Systems Society Technical. For information, call 1 (514) 408-6158, or email Info@MEMSConference.com. www.memsconference.com

AUGUST 27-30 — INTEL DEVELOPER FORUM - San Jose, California. Provides developers with timely technical content, vision and community resources needed to succeed in creating innovative products for the Internet economy. For more information, contact Wendy Laugesen at wendy.laugesen@key3media.com or 1 (650) 372-7968. developer.intel.com/idf

SEPTEMBER 5-7 — DEMOMOBILE - La Jolla, CA. Check out the newest mobile computing technologies and gadgets. Chris Shipley and Jim Forbes find the latest and greatest. For more information, call 1 (800) 633-4312. www.demomobile.com

SEPTEMBER 10-12 — FOURTH ANNUAL HR TECHNOLOGY CONFERENCE & EXPO - Baltimore, MD. For senior human resources executives who finally need to learn this IT stuff or find a new job. Produced by Human Resources Executive magazine. For more information, call 1 (800) 727-1227; email lrpconf@lrp.com. www.hrtechconference.com

SEPTEMBER 13-14 — PEER2PEER WORLD EUROPE - London, England. Will address the strategic, technical and people challenges and opportunities faced by the industry and the end-user. To register, call 44 (20) 7242-2324, fax 44 (20) 7242-2320. www.peer2peer-world.com

SEPTEMBER 18-21 — O'REILLY PEER-TO-PEER AND WEB SERVICES CONFERENCE - Washington, DC. O'Reilly's second P2P extravaganza, featuring Clay Shirky, Larry Lessig, David Stutz, Rep. Tony Boucher, Microsoft's Dave Stutz and the leaders of many grassroots networking projects. For more information, email p2pweb01@oreilly.com or call 1 (800) 998-9938. conferences.oreilly.com/p2p K

OCTOBER 1-5 — FALL INTERNET WORLD - New York, NY. The mother of all Internet trade shows makes its east coast stop. To register, call 1 (800) 632-5537; fax, 1 (203) 559-2814. www.internetworld.com K

Calendar of High-Tech Events

OCTOBER 14-17	EC'01 - Tampa, FL. ACM Conference on Electronic Commerce covers all areas of electronic commerce, focused on computer science issues, but interdisciplinary as well. Register online or email ec01.general@umich.edu. General inquiries about ACM, call 1 (212) 869-7440. www.acm.org/sigs/sigecom/EC01/
OCTOBER 15-18	FALL 2001 VOICE ON THE NET - Atlanta, GA. Pulver.com's biannual Internet telephony fest. Learn about the latest developments in the world of convergence. For information, call 1 (631) 547-0800; email, von2001@pulver.com. pulver.com/von
OCTOBER 18-20	SECOND KYOTO MEETING ON DIGITAL CITIES - Kyoto, Japan. Brings together computer science and social science people concerned with digital cities. Contact JST Digital City Research Center, 81 (75) 257-6214, fax 81 (75) 257-6216. General information, email meeting@digitalcity.jst.go.jp. www.digitalcity.jst.go.jp/meeting/
OCTOBER 19-21	NURTURING THE CYBERCOMMONS 1981-2021 - Ann Arbor, MI. Computer Professionals for Social Responsibility looks at the history and future of the global cybercommons, including Internet governance, "openness," virtual communities, election technology, etc. Contact Nathaniel Borenstein, nsb@cpsr.org. For CPSR contact information, call 1 (650) 322-3778, fax 1 (650) 322-4748. www.cpsr.org/conferences/annmtg01/
OCTOBER 31 - NOVEMBER 4	ICEC 2001 - Vienna, Austria. The first International Center for Electronic Commerce conferences to be held in Europe. Special emphasis on EC firms and government bodies concerned with e-government. To register, contact Johanna Leithner, 43 (1) 515-14242, fax 43 (1) 5124-226, or email johanna.leithner@intropa-dmc. info.tuwien.ac.at/icec2001/
NOVEMBER 5-9	NEXT GENERATION NETWORKS 2001- Boston, MA. The 15th annual conference organized by John McQuillan and Business Communications Review. Covers the alphabet soup of networking technologies, including broadband access, wireless and optical networking. www.ngn2001.com
NOVEMBER 7-9	EDVENTURE'S HIGH-TECH FORUM - Berlin, Germany. Get connected! Our 12th year in Europe. Call Daphne Kis, 1 (212) 924-8800; fax, 1 (212) 924-0240; daphne@edventure.com; www.edventure.com E K

E Events Esther plans to attend.
K Events Kevin plans to attend.

Lack of a symbol is no indication of lack of merit. The full, current calendar is available on our Website, www.edventure.com. Please contact Karen Schrier (karen@edventure.com) to let us know about other events we should include.

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